MC&A 101

NMMSS MC&A Training Subgroup

Topical Areas

- MC&A – Who, What and Why
- Consequences of Ineffective MC&A
- Nuclear Fuel Cycle
- Other Topics
- Alphabet Soup – Acronyms
- Reporting
- Training
- Resources

Regulatory Agencies

- Regulatory agencies within the United States:
  - Department of Energy (DOE)
  - National Nuclear Security Administration (NNSA)
  - Nuclear Regulatory Commission (NRC)
- The International Atomic Energy Agency (IAEA) for countries that have signed Agreements.

What is MC&A?

MC&A stands for

Material Control and Accountability or Accounting (NRC)

NMC&A stands for

Nuclear Material Control and Accountability

The branch of nuclear materials management that deals with providing a system for accounting and controlling the use of and information about nuclear materials in process and storage at nuclear material facilities.

Why MC&A?

- To provide assurance that nuclear materials are accounted for properly
- To provide timely detection of theft or diversion of nuclear materials (timely is relative to operation – may be annual)
- To act as an integral component of the safeguards system for the overall protection of nuclear materials
- To ensure regulatory and reporting compliance
- To provide for the common defense and security and does not constitute an unreasonable risk to public health and safety

Why is MC&A Important?

- How do we really know when and how much nuclear material is missing, and how do we deter the potential diverter?

Answer: Only with effective MC&A.

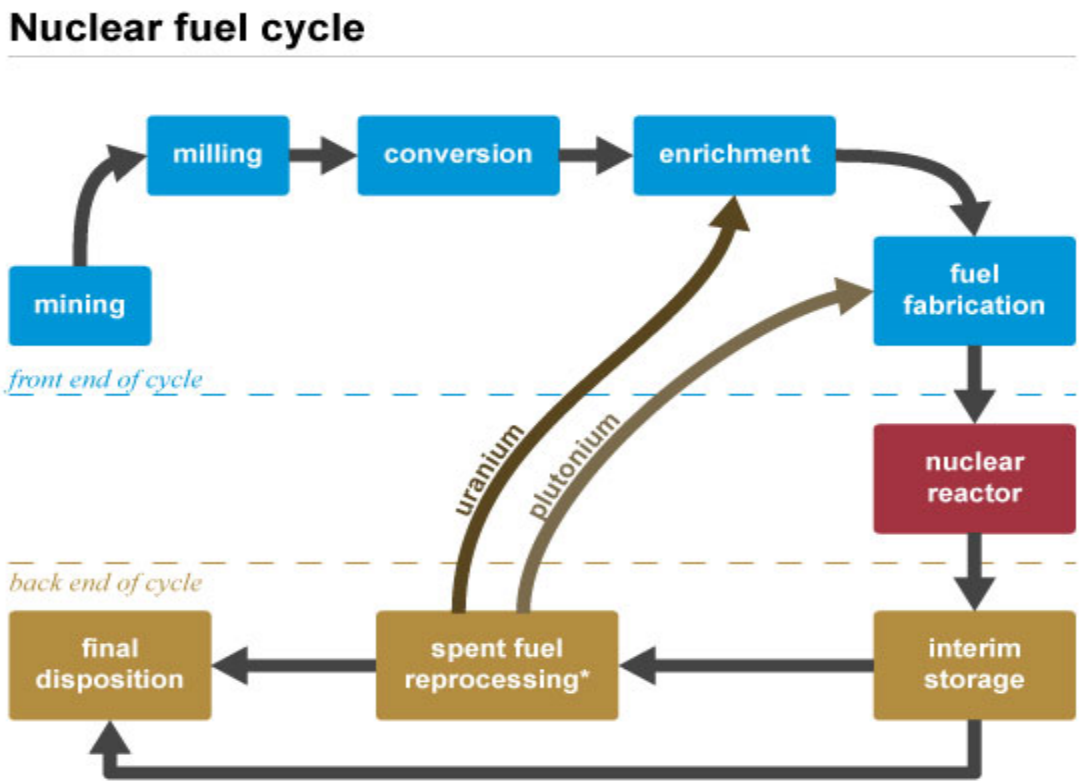
Potential Consequences of Ineffective MC&A

- Undetected Diversion/Theft
- Unexplained Losses (or Gains)
- Vulnerability for Adversarial Attack
- Loss of credibility with regulating bodies
  - Shutdown of Operations/Facilities
  - Notification of Violations/Fines
  - Impacts to international agreements
- Poor Environmental Stewardship
- Public Perception
- International Nuclear Threat

MC&A of Elements

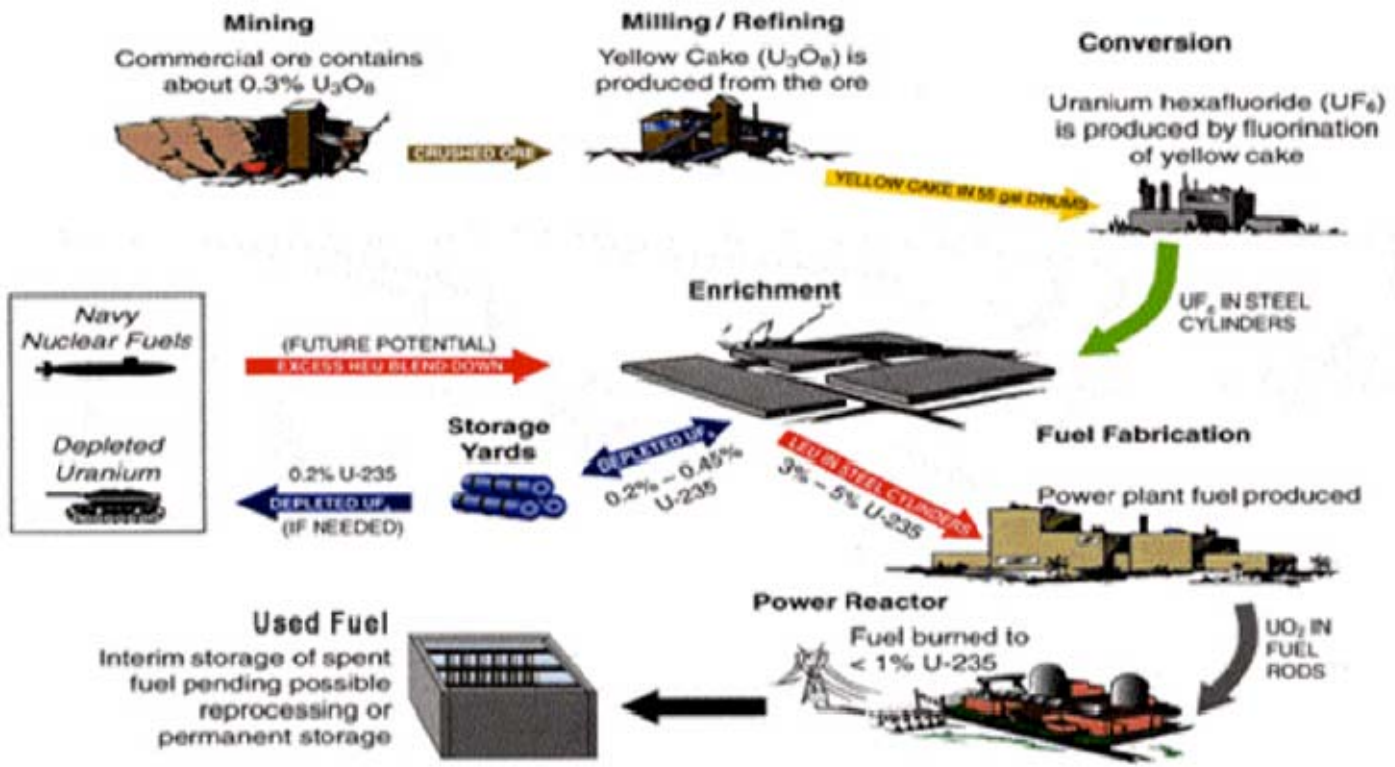
- Program Management
- Materials Control
- Measurements
- Material Accounting
- Physical Inventory

Nuclear Fuel Cycle



**Spent fuel reprocessing* is omitted from the cycle in most countries, including the United States.*

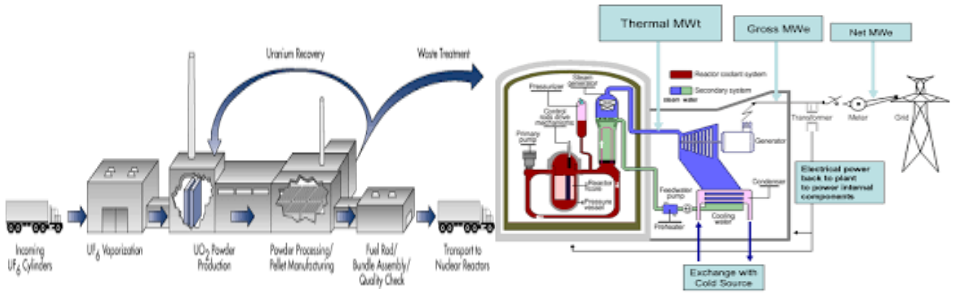
Nuclear Fuel Cycle - continued



Accountable Nuclear Materials

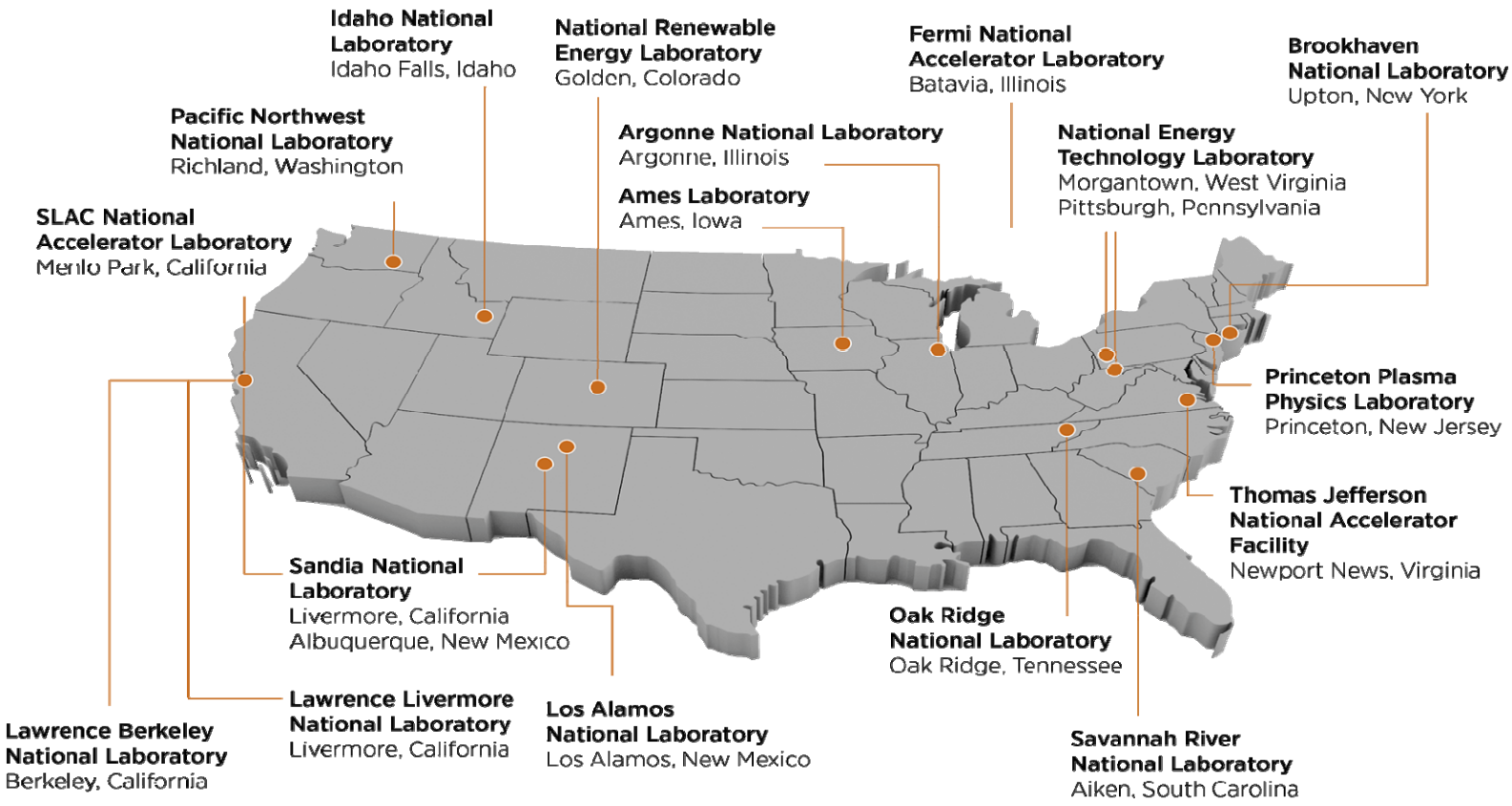
- Accountable nuclear materials from the nuclear fuel cycle:
  - Fissile materials (Enriched Uranium, Plutonium, Neptunium, Americium)
  - Source materials used to produce fissile materials (Depleted and Normal Uranium, Thorium)
  - Other materials of special interest, e.g., Tritium, Californium, Curium

Gas Centrifuge
Gas centrifuge enrichment is the current process by which commercial enrichment is being performed in the United States. UF_6 gas is placed in a gas centrifuge cylinder and rotated at a high speed.



Commercial Nuclear Power Reactors

National Laboratories



Special Nuclear Materials

Special Nuclear Materials				
Material Type	Reportable Quantity	Weight Field Used for Element	Weight Field Used for Isotope	Material Type Code
Enriched Uranium	gram	total U	U-235	20
Uranium-233	gram	total U	U-233	70
Plutonium-242 (Pu)	gram	total Pu	Pu-242	40
Plutonium-239-241 (Pu)	gram	total Pu	Pu-239 + Pu-241	50
Plutonium-238 (Pu)	tenth of a gram	total Pu	Pu-238	83
Uranium in Cascade	gram	total U	U-235	89

*With no GDPs and conversion of LES to IAEA, MT89 is not used within the United States.

Other Accountable Nuclear Materials

Other Accountable Nuclear Materials				
Material Type	Reportable Quantity	Weight Field Used for Element	Weight Field Used for Isotope	Material Type Code
Depleted Uranium (U)	kilogram	total U	U-235	10
Normal Uranium	kilogram	total U	-	81
Americium-241 (Am)	gram	total Am	Am-241	44
Americium-243	gram	total Am	Am-243	45
Berkelium (Bk) site-level	microgram	-	Bk-249	47
Californium-252 (Cf)	microgram	-	Cf-252	48
Curium (Cm)	gram	total Cm	Cm-236	46
Deuterium (D)	tenth of a kilogram	D2O	D2	86
Enriched Lithium (Li)	kilogram	total Li	Li-6	60
Neptunium-237 (Np)	gram	Total Np	-	82
Thorium (Th)	kilogram	total Th	-	88
Tritium (H-3)	gram	total H-3	-	87

Common MC&A Terminology

- Common related names/acronyms:
  - NMC&A, MC&A, Safeguards & Security (S&S)
- Nuclear Material (NM)
- Special Nuclear Material (SNM)
- Material Balance Area (MBA)
- Item Control Areas (ICA)
- Book Inventory (BI)
- Physical Inventory (PI)
- Inventory Difference (ID) or Material Unaccounted For (MUF)
- Shipper/Receiver Agreement (S/RA)
- Shipper/Receiver Difference (S/RD)
- Tamper-Indicating Device (TID)
- Graded Safeguards

Control

- All NM identified and recorded with measured/defensible values.
- At a minimum, annually complete physical inventory verification and reconciliation to book inventory as required by regulatory and reporting requirements.
- All NM located and controlled within defined Material Balance Areas (MBAs) and Item Control Areas (ICAs) that have boundaries that do not overlap.
- Access requirements enforced for facilities, nuclear information databases, areas within a facility, etc.
- Procedures established for handling, processing, inventorying and reporting on nuclear materials
- Personnel surveillance when working in nuclear material areas*
- Material containment and surveillance systems*

*Graded approach

Accounting Control Indicators

- Missing Item(s)
- Inventory Difference (ID) indicates loss (or gain) of nuclear material from the accounting system
  - ID = Book Inventory – Physical Inventory (during inventory periods)
  - ID = Beginning Inventory + Receipts – Shipments – Ending Inventory
    - ID = BI + R – S - EI
- The Shipper/Receiver Differences (S/RD) results from comparing the inventory records of the shipping facility with the receiving facility.

Accountability

- Terms used to describe the data analysis that is conducted to detect material loss, theft or diversion:
  - Accountability
  - Accounting
  - Accountancy
- It consists of the methods and practices used for tracking and declaring what materials are present, in what form, in what quantities, and in what locations, with clearly defined roles and responsibilities.
- Generally Accepted Accounting Principles (GAAP) are the standard framework of guidelines for financial accounting used in any given jurisdiction; generally known as accounting standards or standard accounting practice.

MC&A System

- The MC&A system functions as a whole to:
  - Provide information on the location and use of nuclear materials,
  - Provide assurance that they are accessed and processed in a manner appropriate to their strategic significance,
  - Monitor that the facilities, personnel, and regulations are adequate to deter and detect diversion of nuclear material from its intended purposes, and
  - Be able to state that “the nuclear material was adequately accounted for”

Elements of MC&A

- Program Management
  - Assessment Program
  - Training Program
- Materials Control
  - Detection
  - Security
- Measurements
  - Material Control
  - Measurement
- Material Accounting
- Physical Inventory

Program Management

- Program Management Objectives:
  - Ensures that documentation is sufficient to maintain a comprehensive, effective, and cost-efficient program to control and account for nuclear materials;
  - Defines MC&A system elements with performance goals that reflect consequence of loss or misuse of the material managed by the program;
  - Must be *graded based on the consequence of loss and contain control and accounting mechanisms for nuclear materials;
  - Establishes and maintains an evaluation program that monitors the effectiveness of the MC&A system;
  - Responds effectively and efficiently to material loss indicators, anomalous conditions, and degradation of system performance; and
  - Management ensures the integration of MC&A with Safeguards & Security and other site programs.

*Graded safeguards may not apply to NRC facilities.

Material Control

- Material Control Objectives:
  - Detect, assess, and deter unauthorized access to nuclear material.
  - Detect, assess, and communicate alarms to response personnel, in time to impede unauthorized use of nuclear material.
  - Provide loss detection capability for nuclear material and, when not in its authorized location, be able to provide accurate information needed to assist in locating the material in a timely manner.
  - The material containment and surveillance program, in conjunction with other security program elements, must have the capability to detect, assess, and respond to unauthorized activities and anomalous conditions/events.
  - In coordination with security organizations, material control measures assure that appropriate protection and controls are applied to nuclear materials according to the quantity and attractiveness of the material.

Material Control Details

- Material Containment
  - Limited Area
  - Protected Area
  - Material Access Area
  - Storage and Vaults
  - Processing Containment
- Access Controls
  - Personnel Access
  - Material Access
  - Data Access
  - Equipment Access
- Material Surveillance
  - Multiple Personnel
  - CCTV
  - Other Mechanisms
- Detection Assessment
  - TIDs
  - Portal Monitoring
  - Waste Monitoring
  - Daily Administrative Checks
  - Other Mechanisms

Measurements

- Measurements Objectives:
  - The measurements program must provide measured values with uncertainties sufficient to detect theft or diversion of nuclear materials.
  - The measurement control program must ensure the quality of measurements made for MC&A purposes.
  - Type of Measurements:
    - Confirmation
    - Verification
    - Accountability

Typical Measurement Techniques

- Mass
  - Mechanical/Electronic Scales
  - Volume and density
- Destructive Analysis (DA)
  - Traditional gravimetry and titrimetry
  - Spectrophotometry – X-ray emissions, inductively coupled plasma, colorimetry and fluorescence
  - Radiometry
  - Mass Spectrometry for isotopes and element
    - Mass Spectrometry
    - Davies-Gray Titration
- Non-Destructive Analyses (NDA)
  - Neutron and gamma spectrometry for element and isotope
  - Calorimetry
    - Active Well Coincidence Counter (AWCC)

Material Accounting

- Material Accounting Objectives:
  - Accurate records of nuclear materials inventory are maintained and transactions and adjustments are made in a timely manner.
  - The accounting system:
    - Provides data and reports on nuclear material sufficient to support local, national, and international commitments;
    - Must accurately reflect the nuclear material inventory and have sufficient controls to ensure data integrity;
    - Provides data for reporting on accountable nuclear material to NMMSS; and
    - Must use MBAs as the basis of the accounting structure with ICAs and key measurement points established to localize and identify IDs.

When Numbers Don't Match

- The best case for the numbers not adding up deals with obligation swaps.
  - For example, facility A receives spent fuel with CA obligations at 4.7%.
  - The obligation is swapped for U.S. at facility B on IAEA "clean" material at 46%. The U and U-235 will not match due to disparity in assay.
  - The obligation is placed on material at 12.67%. Once again the U and U-235 will not match. Do you match U and U-235 to meet the equivalent material, chemical form, etc? Well, it can't be done. You have to decide to match/track on U-235 at best.
- Variation in measurement methods represents another example:
  - Material from facility A being shipped to facility B. U and U-235 values from facility A are poor at best.
  - Facility B holds material and does not re-measure because method would not add value. Facility B will use original shipper's values from facility A when shipping. Facility B ships to facility C to process the material in question.
  - Facility C provides U and U-235 obtained through processing. Facility C reports adjustment to facility B's values via corrected 741. Facility B adjusts receipt 741 from facility A to report delta.
  - Facility A reports the ID that results from facility C's measurements. All this requires shipper/receiver agreements between parties (A/B and B/C).

Physical Inventory

- Physical Inventory
  - The physical inventory, in conjunction with other MC&A elements, assures that accountable nuclear materials are not missing.
  - The physical inventory program ensures that discrepancies between the physical inventory and the accounting records system are detected and resolved.

Other Topics

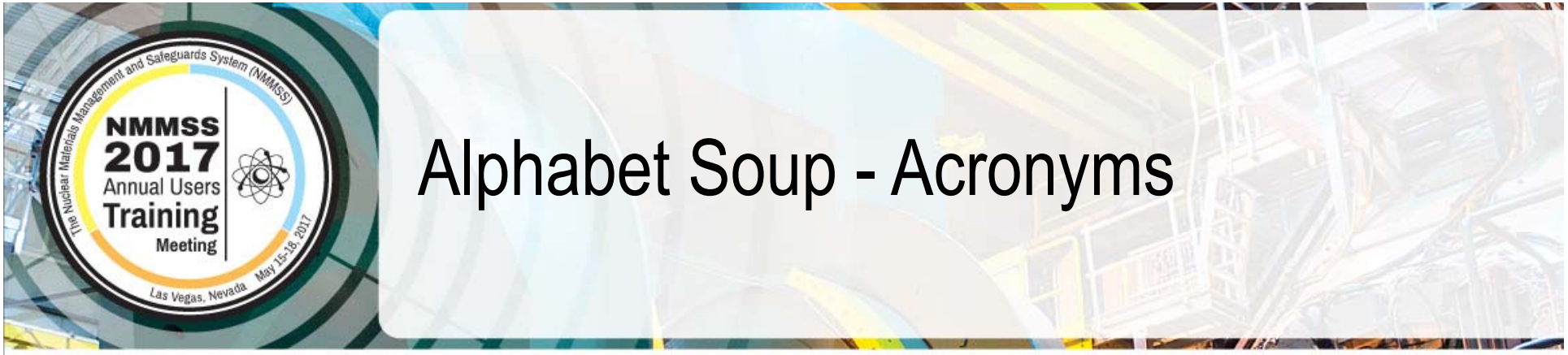
- Obligations
  - Obligations can be attached beyond source material and enrichment.
  - Obligations can be assigned to material through the use of obligated equipment.
- NMMSS Reporting Process
  - Submission to NMMSS
  - Verification of error free/receipt through TJ-1X
  - Checks between facility “Book” to NMMSS records (A-200)
- SAMS 8.0 versions
  - Authority Reference files updated by NMMSS every year (new disk available at NMMSS users meeting or by sending a request to NMMSS staff).
  - Project Numbers can be out-of-date causing error, but user can exclude error.
  - Exempted errors in SAMS will change the process code from A to C in the XML that is created. If this is original dataset, the C needs to be changed to an A process code. Can’t have C without A if this dataset is the first dataset submitted to NMMSS.

Other Topics (continued)

- Questions
  - Questions can be answered by NMMSS staff.
  - Questions can also be answered by SME within the MC&A industry.
- DOE to NRC shipment/receipts
  - A receipt from DOE can provide opportunities for codes not used by the receiving NRC facility (e.g., Nature of Transaction [TI Code]. To/From Accounts, receipt of G owner code material).
  - Ask the shipping facility for clarification and requirement for these codes.
  - Cooperation is essential to prevent generating errors during NMMSS edit checks.
- If I am a Waste Facility and receive a waste shipment from DOE, why do I get an error from NMMSS on volume?
  - An edit check in NMMSS associates “V” RIS with allowing volume. Even if you are a waste facility where your RIS begins with an X, Y, or Z, the edit will generate an error that must be exempted by NMMSS staff.

Other Topics (continued)

- Where can I find the appropriate COEI Code?
  - NMMSS can provide I-027, Composition of Ending Inventory Report for your facility.
  - LANMAS has COEIDetail table.
- The I-17 DOE Inventory Profile report (obsolete).
  - Headquarters discontinued this report because every request made by a facility to add a material to their profile was approved (e.g., no disapprovals). Due to this trend/practice, it was decided that maintaining a COEI profile was no longer necessary. The last available report has a date of April 24, 2008. It is obsolete and is no longer available from NMMSS. There is one reference in the NMIA Guide to I-17 in Table A1-1.
- The I-027 Composition of Ending Inventory By Facility report.



Alphabet Soup - Acronyms

- AC – Action Code
- ASTM – American Society for Testing and Materials
- ATS – Authorization To Ship
- AWCC – Active Well Coincidence Counter
- BI – Beginning Inventory
- CFR – Code of Federal Regulations
- COEI – Composition of Ending Inventory
- D-2 – DOE Directory of Reporting Identification Symbols
- D-3 – NRC Directory of Reporting Identification Symbols
- D-15 – International Nuclear Facilities
- DA – Destructive Analysis
- DAC – Daily Administrative Checks
- DMT – Detail Material Type
- DOE – United States Department of Energy
- EI – Ending Inventory
- EURATOM – The European Atomic Energy Community
- FNMC – Fundamental Nuclear Material Control
- ICA – Item Control Area
- ICR – Inventory Change Report
- ID – Inventory Difference
- IDC – Item Description Code
- IDES – Item Description
- IAEA – International Atomic Energy Agency
- KMP – Key Measurement Point
- MBA – Material Balance Area
- MBR – Material Balance Report (M-742)
- MC&A – Materials Control and Accountability
- MT – Material Type
- MTC – Material Type Code
- NDA – Non-Destructive Analysis
- NMC&A – Nuclear Material Control and Accountability
- NMIA – Nuclear Materials Inventory Assessment

Alphabet Soup – Acronyms (continued)

- NMMSS – Nuclear Materials Management and Safeguards System
- NMR – Nuclear Materials Representative
- NNSA – National Nuclear Security Administration
- NOL – Normal Operational Loss
- NRC – United States Nuclear Regulatory Commission
- OMB – Office of Management and Budget
- ONMI – Office of Nuclear Material Integration (NA-532)
- PC – Processing Code
- PIL – Physical Inventory Listing
- RIS – Reporting Identification Symbol
- SAMS – Safeguards Management Software
- SEL – Specific Export License
- SMT – Summary Material Type
- SNM – Special Nuclear Material
- TIC – Type of Inventory Change
- TID – Tamper-Indicating Device
- WR – Former Soviet Union Weapons Material
- XML – eXtensible Markup Language

A Foreign Language?

- Here are some examples using acronyms to point out that sometimes we talk in a foreign language to a new comer to the MC&A world.
  - LES needs to know what TIC and what To/From Accounts to use on the 741 when reporting their AB to NMMSS?
  - We need to check with ORNL to see if they require an ATS prior to sending our shipment.
  - DOE is coming to SRS to evaluate the integrity of our TID program and DAC.
  - NMMSS sent a TJ-1X. The project number, COEI and SMT were incorrect. The transaction should have been processed through SAMS.
  - OMB provides new dates for the 741, MBR, and PIL when these forms reach their expiration date.
  - The NMIA needs to be submitted to ONMI. We need to check the LRIS, COEI, MTC, IDES and SFMB values in our file.
  - As part of closing, I need to submit my DP742-C, DP749, and DP740 files to NMMSS.
  - Do you want me to generate the PIL at the SMT, DMT or COEI report level?
  - I traveled to NNSS for a NMMSS meeting and picked up our RIS's copy of the D-2, D-3 and D-15 disk.
  - LANL is requesting you send your A/A XML file to import into LANMAS.
  - Check the NMMSS A-200 and M-742 during reconciliation of book to physical.

National Training Center – MC&A Training

- NMM-112, Nuclear Materials Management and Safeguards System (NMMSS) I
- NMM-212, Nuclear Materials Management and Safeguards System (NMMSS) II
- MCA-101DE, Introduction to Nuclear Material Control and Accountability (online course – 4 hrs.)
- MCA-103DE, Transaction Data Systems (TDS) (online course)
- MCA-110, Basics of Nuclear Material Accountability (instructor-led course)
- MCA-113, Inventory Difference Accounting (instructor-led course)
- MCA-114, Local Area Nuclear Material Accountability Software Administrator's Course (instructor-led course)
- MCA-120, Basics of Nuclear Material Control (instructor-led course)
- MCA-130, Statistical Concepts in Nuclear Material Control and Accountability (instructor-led course)
- MCA-132, Sampling Plans for Nuclear Material Control and Accountability (instructor-led course)
- MCA-150, Nuclear Material Control and Accountability Survey Procedures (instructor-led course)
- MCA-153, Introduction to Performance Testing for Nuclear Material Control and Accountability (instructor-led course)
- MCA-214, Local Area Nuclear Material Accountability Software (instructor-led course)
- MCA-224, Local Area Nuclear Material Accountability Software Advanced User's Course (instructor-led course)
- MCA-260, Physical Inventory for Nuclear Material Control and Accountability (instructor-led course)

Site-specific Training

- Site-specific training can vary based on regulatory body and facility mission. Here are some examples:
  - Daily Administrative Checks
  - MBA Custodian
  - TID Applier
  - TID Custodian
  - Two-Person Rule

Resources

The Nuclear Materials Management and Safeguards System (NMMSS)

NMMSS

Mission

U.S. Government's *Official Database* to track transactions, movements, and inventories of nuclear materials throughout the U.S. as well as imports and exports

Jointly funded by the **NRC and NNSA** – Managed by **NA-532**

Over 420 Government and commercial nuclear entities currently report to NMMSS

DOE/NNSA
- Defense Programs
- Naval Propulsion
- Nuclear Energy
- Science
- Environmental Management

Fuel Cycle Facilities
- Conversion
- Enrichment
- Fuel Fabrication
- Power Reactors, etc.

Medical, Academic, and Research
- Hospitals
- Universities
- Laboratories, etc.

Products & Services

Manage Critical & Time-Sensitive Nuclear Material Information
- Required U.S. reporting to the International Atomic Energy Agency (IAEA) under international safeguards agreements
- Nuclear materials financial management (asset tracking for the CFO's office)
- Critical support of regulatory functions, including NRC and DOE/NNSA MC&A inspections
- Demonstrate compliance with peaceful use agreements for nuclear commerce
- Public and worker health studies

Reconciliation of DOE & Civilian Nuclear Material Inventories
- Current inventories
- Restricted use material

Training to Strengthen Domestic & International Nuclear Material Accounting Practices
- Annual training forum
- Periodic topical courses during the year
- International mentoring and outreach

Specialized Reports & Analysis
- Highly Enriched Uranium inventories
- Plutonium
- Advocate support to National Security Council, State Department, etc.
- Yearly report to the IAEA to document plutonium holdings

Office of Nuclear Material Integration (ONMI), NA-532

Resources – DOE/NNSA

- DOE Manual 474.2 Chg 4, *Nuclear Material Control and Accountability* establishes performance objectives, metrics, and requirements for developing, implementing, and maintaining a nuclear material control and accountability (MC&A) program within the U.S. Department of Energy (DOE), including the National Nuclear Security Administration (NNSA), and for DOE owned materials at other facilities that are exempt from licensing by the Nuclear Regulatory Commission (NRC).
- DOE O 410.2 Chg 2, *Management of Nuclear Materials* establishes requirements for the lifecycle management of DOE owned and/or managed accountable nuclear materials.
- Nuclear Materials Management and Safeguards System (NMMSS) Users Guide

https://nnsa.energy.gov/sites/default/files/nnsa/04-13-inlinefiles/2013-04-08%20Nuclear%20Materials%20Management%20and%20Safeguards%20System%20Users%20Guide%20Rev%202%20April%202013.pdf

Resources – NRC

- NUREG/BR-0006, Instructions for Completing Nuclear Material Transaction Reports, which contains the detailed instructions to NRC and Agreement State licensees for reporting nuclear material transfers on DOE/NRC Form 741 - Nuclear Material Transaction Report and DOE/NRC Form 740M - Concise Note.

- NUREG/BR-0007, Instructions for the Preparation and Distribution of Material Status Reports, which contains the detailed instructions to licensees for the preparation and distribution of DOE/NRC Form 742 pertaining to Material Balance reporting and DOE/NRC Form 742C pertaining to Physical Inventory Listing (PIL).

- Title 10, Code of Federal Regulation, Chapter 1, "Nuclear Regulatory Commission", contains the regulations applicable to NRC and "Agreement State" licensees involved in activities concerning nuclear materials not subject to DOE requirements.

- Regulatory Guide 5.29, “Special Nuclear Material Control and Accounting Systems for Nuclear Power Plants,” endorses ANSI N15.8-2009 as an acceptable approach to meet the MC&A requirements in Subpart B of 10 CFR Part 74 at nuclear power plants.

Draft NUREG Plans:

- NUREG 1280 Acceptable Standard Format and Content for the Material Control and Accounting (MC&A) Plan Required for Strategic Special Nuclear Material
- NUREG 1065 Acceptable Standard Format and Content for the Material Control and Accounting (MC&A) Plan Required for Special Nuclear Material of Low Strategic Significance
- NUREG 2158 Acceptable Standard Format and Content for the Material Control and Accounting (MC&A) Plan Required for Low-Enriched Uranium Enrichment Facilities

Draft NUREG for Category II Facilities:

- NUREG 2159 Acceptable Standard Format and Content for the Material Control and Accounting (MC&A) Plan Required for Special Nuclear Material of Moderate Strategic Significance

Backup Slides

- Regulatory Agencies
- Detail Material Types Codes
- Nuclear Power Reactors
- Operating Research and Test Reactors
- NMMSS Contact Information
- I-027 COEI By Facility Example
- LANMAS COEIDetail table Example
- I-017 Inventory Profile Example

Regulatory Agencies

- Department of Energy (DOE) regulates government-owned nuclear materials within DOE facilities
- National Nuclear Security Administration (NNSA) - a semi-autonomous agency within (DOE) responsible for nuclear weapons stockpile, nuclear propulsion, and responds to nuclear and radiological emergencies.
- Nuclear Regulatory Commission (NRC) regulates nuclear materials within the private sector facilities (enrichment, fuel fabrication, power reactors, research reactors, universities and hospitals)

NUCLEAR MATERIAL TYPE CODES

Type Code	Type Description	Reporting Unit	Type Code	Type Description	Reporting Unit
	Uranium Depleted in U-235		44	Americium 241	gm
10	Total		45	Americium 243	gm
11	< 0.21% U-235	kg	46	Curium	gm
12	0.21% to < 0.24% U-235	kg	48	Californium	microgram
13	0.24% to < 0.26% U-235	kg		Plutonium	
14	0.26% to < 0.28% U-235	kg	50	Total	
15	0.28% to < 0.31% U-235	kg	51	< 4.00% Pu-240	gm
16	0.31% to < 0.50% U-235	kg	52	4.00% to < 7.00% Pu-240	gm
17	0.50% to < 0.60% U-235	kg	53	7.00% to < 10.00% Pu-240	gm
18	0.60% to < 0.710% U-235	kg	54	10.00% to < 13.00% Pu-240	gm
	Uranium Enriched in U-235		55	13.00% to < 16.00% Pu-240	gm
20	Total		56	16.00% to < 19.00% Pu-240	gm
21	> 0.712 to < 0.90% U-235	gm	57	19.00% and above Pu-240	gm
22	0.90 to < 1.15% U-235	gm		Lithium Enriched in Li-6	
23	1.15 to < 1.60% U-235	gm	60	Total	kg
24	1.60 to < 2.00% U-235	gm	61	> Normal (7.42%) to < 55.00%	kg
25	2.00 to < 2.60% U-235	gm	62	55.00% to < 80.00%	kg
26	2.60 to < 2.90% U-235	gm	63	80.00% and above	kg
27	2.90 to < 3.10% U-235	gm		Uranium Enriched in U-233	
28	3.10 to < 3.40% U-235	gm	70	Total	
29	3.40 to < 3.90% U-235	gm	71	< 5 ppm U-232	gm
30	3.90 to < 4.10% U-235	gm	72	5 to < 10 ppm U-232	gm
31	4.10 to < 5.00% U-235	gm	73	10 to < 50 ppm U-232	gm
32	5.00 to < 10.00% U-235	gm	74	50 ppm and above U-232	gm
33	10.00 to < 20.00% U-235	gm	81	Normal U	
34	20.00 to < 35.00% U-235	gm		Total	
35	35.00 to < 45.00% U-235	gm		0.710 to $\leq$ 0.712% U-235	kg
36	45.00 to < 80.00% U-235	gm	82	Np 237 Total	gm
37	80.00 to < 92.00% U-235	gm	83	Pu 238 Total	gm to tenth
38	92.00 to < 94.00% U-235	gm	86	D_2 Total	kg to tenth
39	94.00 and above U-235	gm	87	Tritium Total	gm to hundredth
	Plutonium 242		88	Thorium Total	kg
40	Total	gm	89	U in Cascades Total	gm
41	20% thru 60%	gm	90	This series is available for local use	
42	> 60%	gm			

Nuclear Power Reactors

- Nuclear power in the United States is provided by 98 commercial reactors with a net summer capacity of 100,350 megawatts (MW), consisting of 64 pressurized water reactors and 34 boiling water reactors, producing a total of 797.2 terawatt-hours of electricity, which accounted for 19.50% of the nation's total electric energy generation in 2015.
- As of 2016, there are four new reactors under construction with a gross electrical capacity of 5,000 MW, while 7 reactors have been permanently shut down since 2013.
- The United States is the world’s largest supplier of commercial nuclear power, and in 2013 generated 33% of the world’s nuclear electricity.

Nuclear Power Reactors

State	Status	Plant	Operator
Alabama	Regulated	Joseph Farley	Southern Nuclear Operating Co.
		Browns Ferry	Tennessee Valley Authority
Arizona	Regulated	Palo Verde	Arizona Public Service Co.
Arkansas	Regulated	Arkansas Nuclear One	Entergy Operations Inc.
California	Regulated	Diablo Canyon	Pacific Gas & Electric Co.
Connecticut	Deregulated	Millstone	Dominion Nuclear Connecticut Inc.
Florida	Regulated	Turkey Point 3 & 4	Florida Power & Light Co.
		St. Lucie	Florida Power & Light Co.
Georgia	Regulated	Edwin Hatch	Southern Nuclear Operating Co.
		Vogtle	Southern Nuclear Operating Co.
Illinois	Deregulated	Braidwood	Exelon Generation Co. LLC
		Byron	Exelon Generation Co. LLC
		Clinton	Exelon Generation Co. LLC
		Dresden	Exelon Generation Co. LLC
		LaSalle	Exelon Generation Co. LLC
		Quad Cities	Exelon Generation Co. LLC
Iowa	Deregulated*	Duane Arnold	NextEra Energy Resources Duane Arnold, LLC
Kansas	Regulated	Wolf Creek	Wolf Creek Nuclear Operations Corp.
Louisiana	Regulated	River Bend	Entergy Operations Inc.
		Waterford 3	Entergy Operations Inc.

Nuclear Power Reactors

State	Status	Plant	Operator
Maryland	Deregulated	Calvert Cliffs	Calvert Cliffs Nuclear Power Plant LLC
Massachusetts	Deregulated	Pilgrim	Entergy Nuclear Operations Inc.
Michigan	Deregulated	Cook	American Electric power Co. Inc.
		Fermi 2	Detroit Edison Co. (The)
		Palisades	Entergy Nuclear Operations Inc.
Minnesota	Regulated	Monticello	Northern States Power Company
		Prairie Island	Northern States Power Company
Mississippi	Regulated	Grand Gulf	Entergy Operations Inc.
Missouri	Regulated	Callaway	AmerenUE
Nebraska	Regulated	Cooper	Nebraska Public Power District
New Hampshire	Deregulated	Seabrook	NextEra Energy Resources Seabrook, LLC
New Jersey	Deregulated	Hope Creek	PSEG Nuclear, LLC
		Oyster Creek	Exelon Generation Co. LLC
		Salem	PSEG Nuclear, LLC
New York	Deregulated	Indian Point	Entergy Nuclear Operations Inc.
		James A. Fitzpatrick	Entergy Nuclear Operations Inc.
		Nine Mile Point	Nine Mile Point Nuclear Station LLC
		Robert E. Ginna	R.E. Ginna Nuclear Power Plant LLC
North Carolina	Regulated	Brunswick	Duke Energy Progress
		Shearon Harris	Duke Energy Progress
		McGuire	Duke Energy Carolinas
Ohio	Deregulated	Davis-Besse	FirstEnergy Nuclear Operating Co.
		Perry	FirstEnergy Nuclear Operating Co.

Nuclear Power Reactors

State	Status	Plant	Operator
Pennsylvania	Deregulated	Beaver Valley	FirstEnergy Nuclear Operating Co.
		Limerick	Exelon Generation Co. LLC
		Peach Bottom	Exelon Generation Co. LLC
		Susquehanna	Susquehanna Nuclear LLC
		Three Mile Island	Exelon Generation Co. LLC
South Carolina	Regulated	H.B. Robinson 2	Duke Energy Progress
		Oconee	Duke Energy Carolinas
		Catawba	Duke Energy Carolinas
		Summer	South Carolina Electric & Gas Co.
Tennessee	Regulated	Sequoyah	Tennessee Valley Authority
		Watts Bar	Tennessee Valley Authority
Texas	Deregulated	Comanche Peak	Luminant Generation
		South Texas Project	STP Nuclear Operating Co.
Virginia	Regulated	North Anna	Virginia Electric and Power Company
		Surry	Virginia Electric and Power Company
Washington	Regulated	Columbia Generating Station	Energy Northwest
Wisconsin	Deregulated*	Point Beach	NextEra Energy Resources Point Beach, LLC

49 nuclear units operate in deregulated states, 49 nuclear units operate in regulated states.

Sources: Energy Information Administration. Regulated states include those that suspended deregulation efforts.

Updated: 7/15

*** Duane Arnold and Point Beach have power purchase agreements even though EIA notes Iowa and Wisconsin as regulated states.**

Nuclear Power Reactors Under Construction

Units under construction				
Name	Type	Capacity (MW_e) net / gross	Construction Start Date	Expected completion
Vogtle 3 (Georgia)	AP1000 (Advanced Passive - PWR)	1,117 / 1,250	March 15, 2013	June 2019
Vogtle 4	AP1000	1,117 / 1,250	November 22, 2013	2020
V.C. Summer 2 (South Carolina)	AP1000	1,117 / 1,250	March 9, 2013	June 2019
V.C. Summer 3	AP1000	1,117 / 1,250	November 2, 2013	June 2020
Total capacity		4,468 / 5,000		

Operating Research & Test Reactors

31 Operating Research and Test Reactors

Aerotest Operations Inc., San Ramon, CA
Armed Forces Radiobiological Research Institute, Bethesda, MD
Dow Chemical Company, Midland, MI
General Electric Company, Sunol, CA
Idaho State University, Pocatello, ID
Kansas State University, Manhattan, KS
Massachusetts Institute of Technology, Cambridge, MA
National Institute of Standards and Technology, Gaithersburg, MD
North Carolina State University, Raleigh, NC
Ohio State University, Columbus, OH
Oregon State University, Corvallis, OR
Penn State University, University Park, PA
Purdue University, West Lafayette, IN
Reed College, Portland, OR
Rensselaer Polytechnic Institute, Schenectady, NY
Rhode Island Atomic Energy Commission, Narrangansett, RI

Operating Research & Test Reactors

31 Operating Research and Test Reactors

Texas A&M University, College Station, TX (two reactors)
University of California-Davis, Sacramento, CA
University of California, Irvine, CA
University of Florida, Gainesville, FL
University of Maryland, College Park, MD
University of Massachusetts, Lowell, MA
University of Missouri, Columbia, MO
University of Missouri, Rolla, MO
University of New Mexico, Albuquerque, NM
University of Texas, Austin, TX
University of Utah, Salt Lake City, UT
University of Wisconsin, Madison, WI
U.S. Geological Survey, Denver, CO
Washington State University, Pullman, WA

Graded Safeguards Slide #15

- GRADED SAFEGUARDS
  - A system designed to provide varying degrees of physical protection, accountability, and material control to different types, quantities, physical forms, and chemical or isotopic compositions of nuclear materials consistent with the risks and consequences associated with threat scenarios.
  - Providing the greatest relative amount of control and effort to the types and quantities of special nuclear material that can be most effectively used in a nuclear explosive device.

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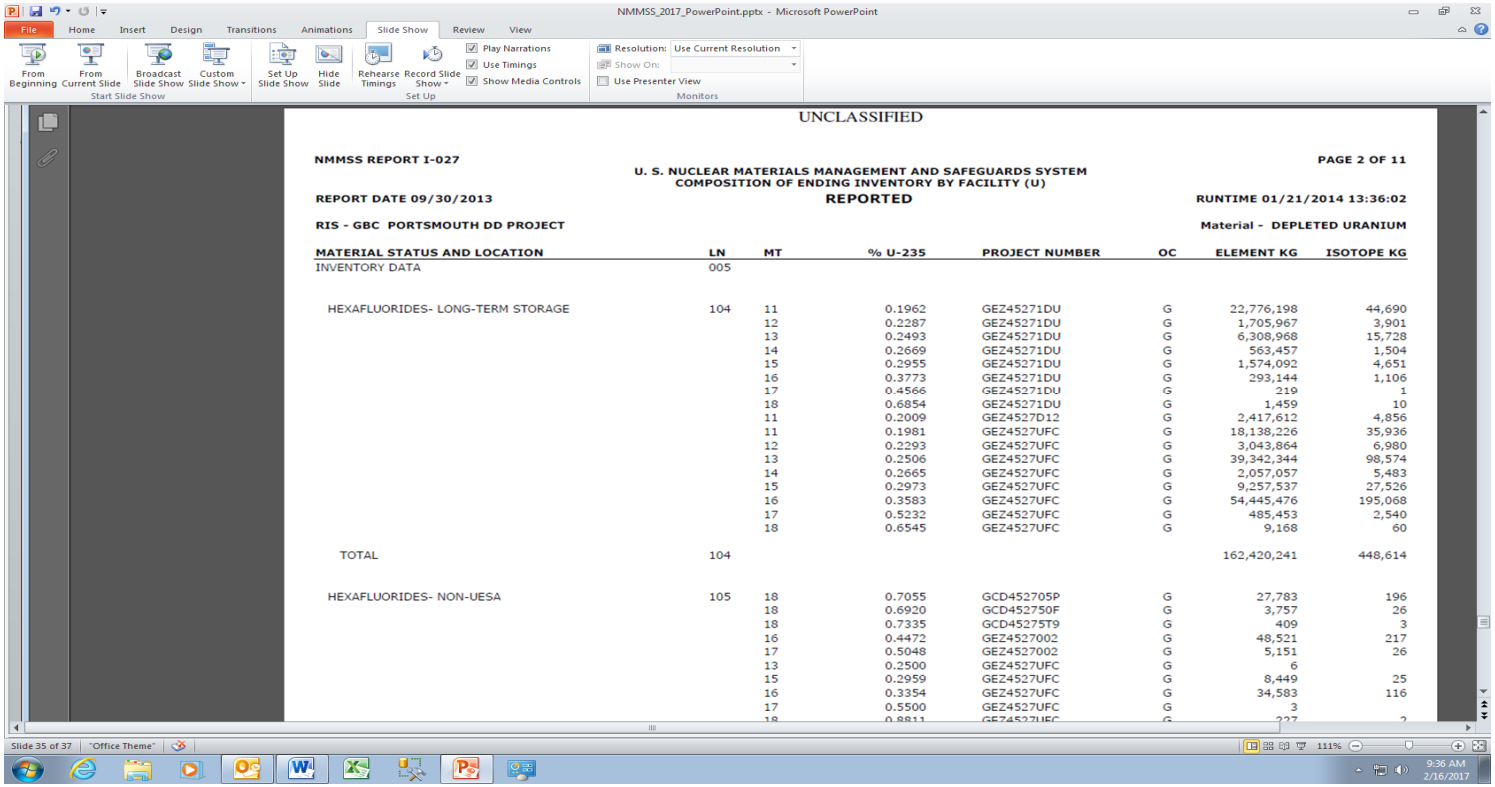
I-027 COEI By Facility



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U. S. NUCLEAR MATERIALS MANAGEMENT AND SAFEGUARDS SYSTEM
COMPOSITION OF ENDING INVENTORY BY FACILITY (U)

REPORT DATE 09/30/2013 — REPORTED — RUNTIME 01/21/2014 13:36:02

RIS - GBC PORTSMOUTH DD PROJECT — Material - DEPLETED URANIUM

MATERIAL STATUS AND LOCATION	LN	MT	% U-235	PROJECT NUMBER	OC	ELEMENT KG	ISOTOPE KG
INVENTORY DATA	005						
HEXAFLUORIDES- LONG-TERM STORAGE	104	11	0.1962	GEZ45271DU	G	22,776,198	44,690
		12	0.2287	GEZ45271DU	G	1,705,967	3,901
		13	0.2493	GEZ45271DU	G	6,308,968	15,728
		14	0.2669	GEZ45271DU	G	563,457	1,504
		15	0.2955	GEZ45271DU	G	1,574,092	4,651
		16	0.3773	GEZ45271DU	G	293,144	1,106
		17	0.4566	GEZ45271DU	G	219	1
		18	0.6854	GEZ45271DU	G	1,459	10
		11	0.2009	GEZ4527D12	G	2,417,612	4,856
		11	0.1981	GEZ4527UFC	G	18,138,226	35,936
		12	0.2293	GEZ4527UFC	G	3,043,864	6,980
		13	0.2506	GEZ4527UFC	G	39,342,344	98,574
		14	0.2665	GEZ4527UFC	G	2,057,057	5,483
		15	0.2973	GEZ4527UFC	G	9,257,537	27,526
		16	0.3583	GEZ4527UFC	G	54,445,476	195,068
		17	0.5232	GEZ4527UFC	G	485,453	2,540
		18	0.6545	GEZ4527UFC	G	9,168	60
TOTAL	104					162,420,241	448,614
HEXAFLUORIDES- NON-UESA	105	18	0.7055	GCD452705P	G	27,783	196
		18	0.6920	GCD452750F	G	3,757	26
		18	0.7335	GCD45275T9	G	409	3
		16	0.4472	GEZ4527002	G	48,521	217
		17	0.5048	GEZ4527002	G	5,151	26
		13	0.2500	GEZ4527UFC	G	6	
		15	0.2959	GEZ4527UFC	G	8,449	25
		16	0.3354	GEZ4527UFC	G	34,583	116
		17	0.5500	GEZ4527UFC	G	3	

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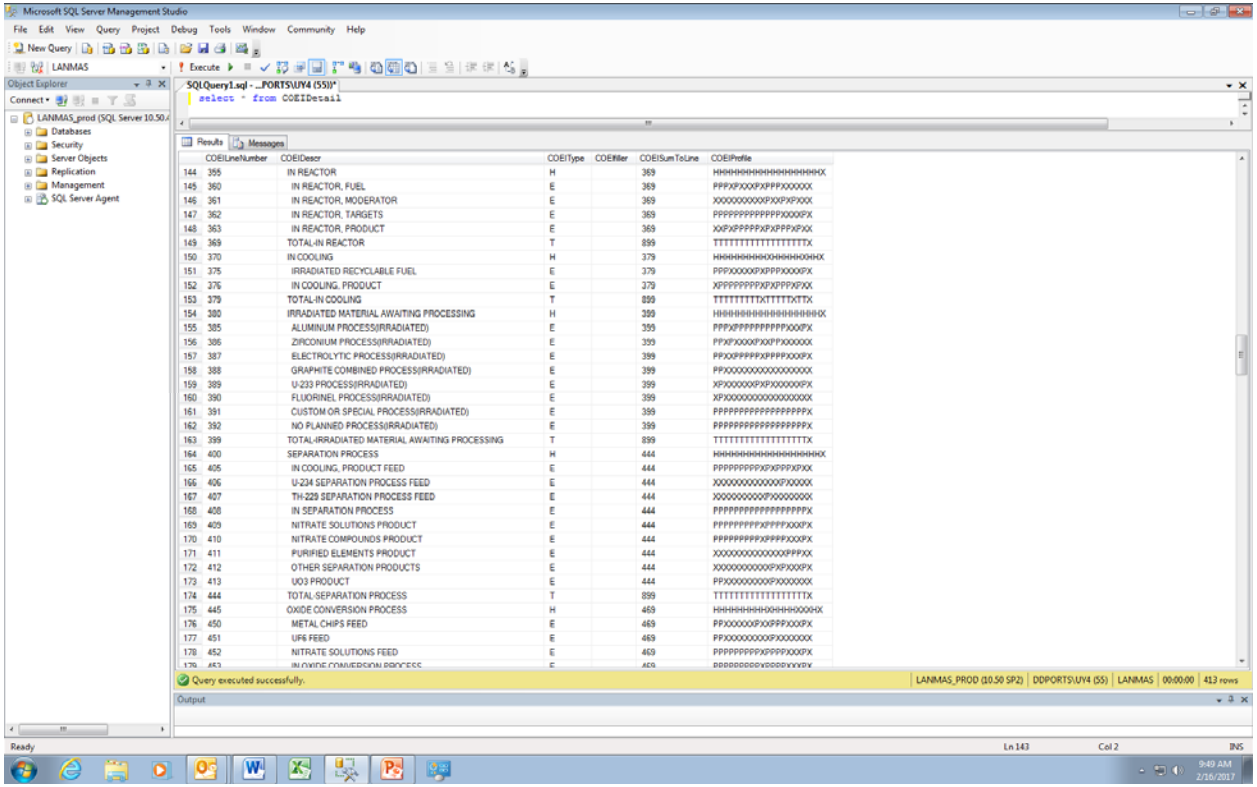
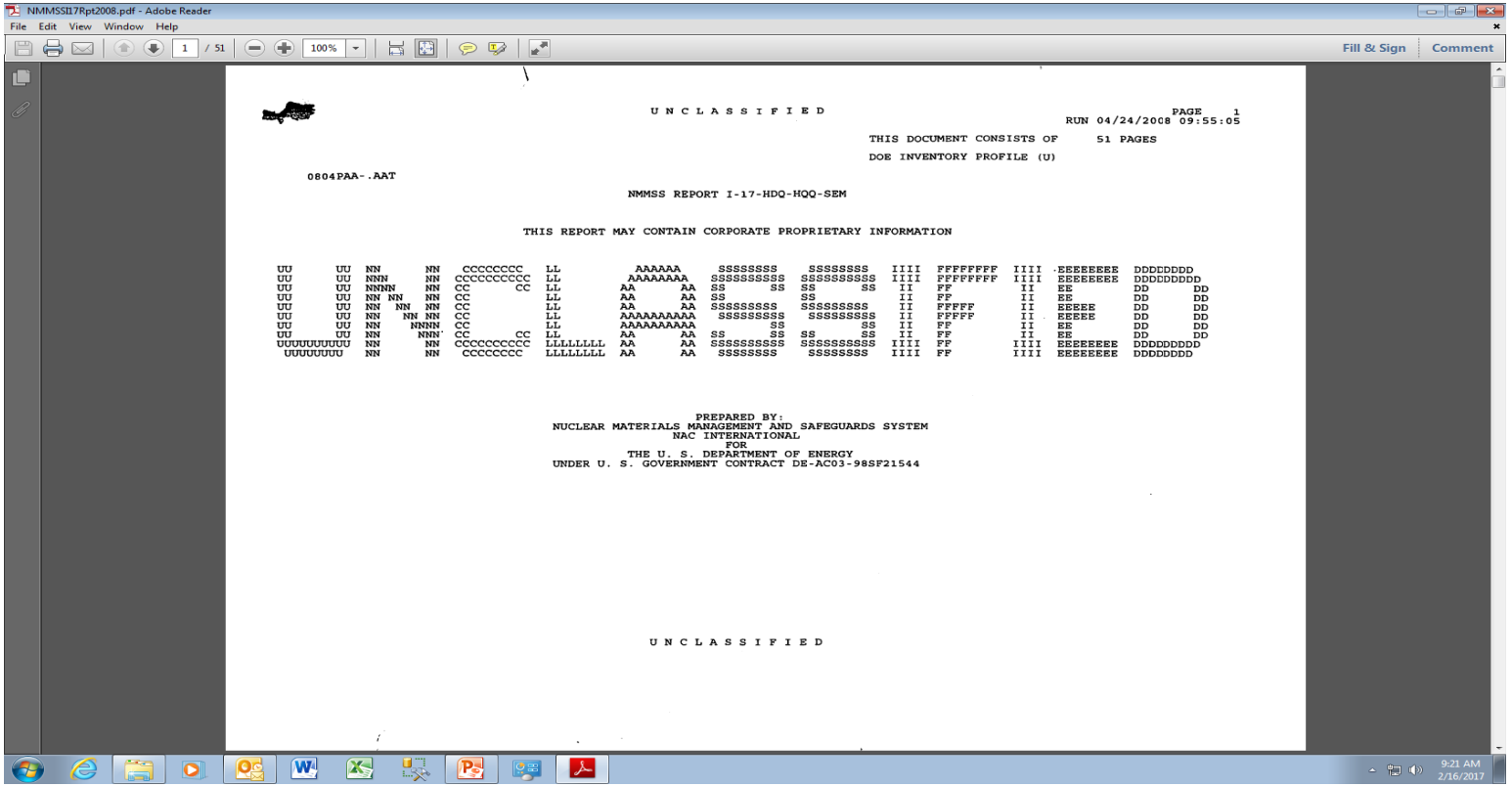
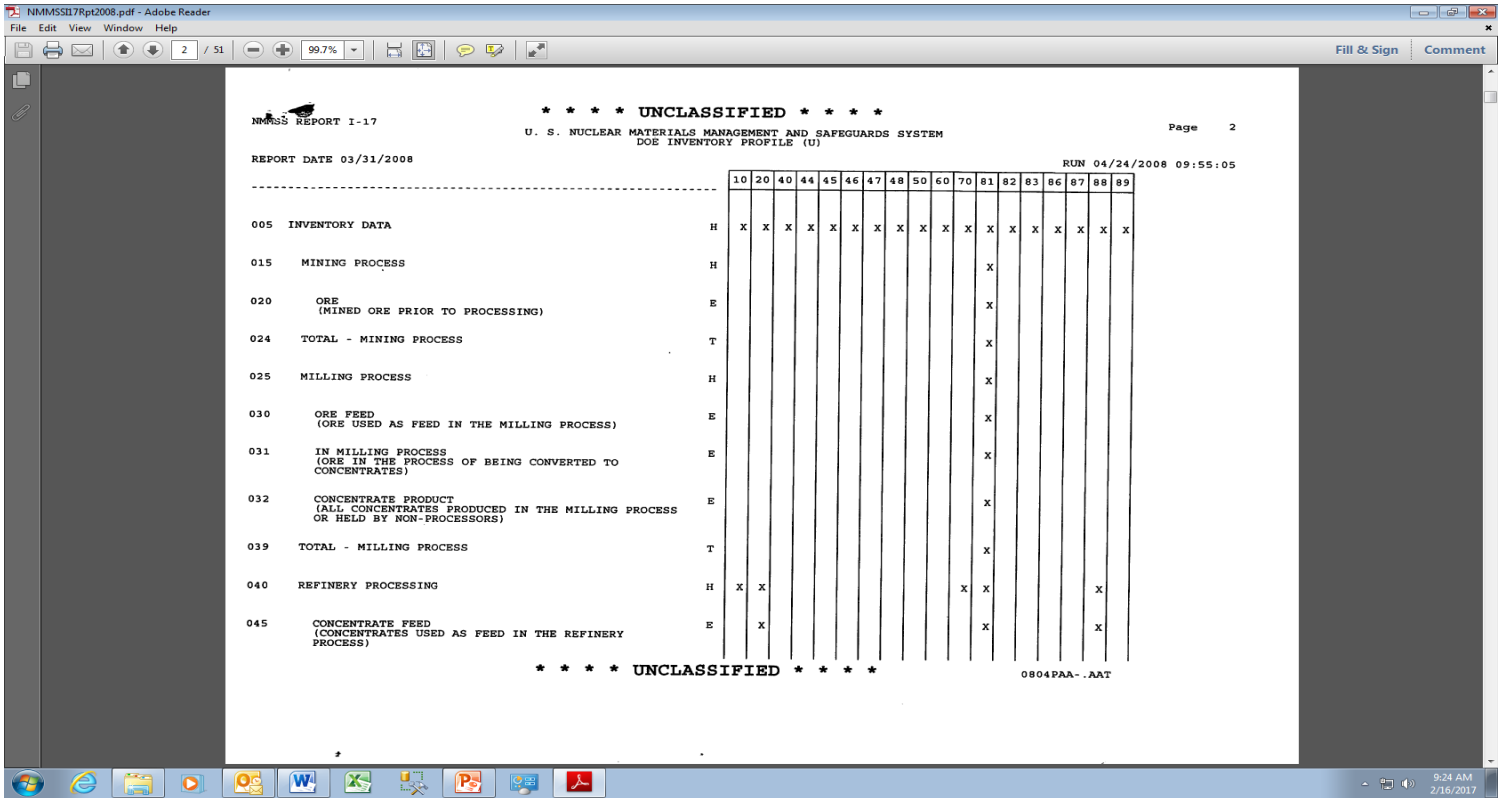


I-17 DOE Inventory Profile (discontinued)



I-17 DOE Inventory Profile (discontinued)



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NMMSS REPORT I-17

U. S. NUCLEAR MATERIALS MANAGEMENT AND SAFEGUARDS SYSTEM
DOE INVENTORY PROFILE (U)

Page 2

REPORT DATE 03/31/2008

RUN 04/24/2008 09:55:05

			10	20	40	44	45	46	47	48	50	60	70	81	82	83	86	87	88	89
005	INVENTORY DATA	H	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
015	MINING PROCESS	H												X						
020	ORE (MINED ORE PRIOR TO PROCESSING)	E												X						
024	TOTAL - MINING PROCESS	T												X						
025	MILLING PROCESS	H												X						
030	ORE FEED (ORE USED AS FEED IN THE MILLING PROCESS)	E												X						
031	IN MILLING PROCESS (ORE IN THE PROCESS OF BEING CONVERTED TO CONCENTRATES)	E												X						
032	CONCENTRATE PRODUCT (ALL CONCENTRATES PRODUCED IN THE MILLING PROCESS OR HELD BY NON-PROCESSORS)	E												X						
039	TOTAL - MILLING PROCESS	T												X						
040	REFINERY PROCESSING	H	X	X									X	X					X	
045	CONCENTRATE FEED (CONCENTRATES USED AS FEED IN THE REFINERY PROCESS)	E		X										X					X	

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